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ENERGY EFFICIENCY IMPROVEMENT IN SMEs – ANALYSIS OF A PILOT PROGRAMME OF ENERGY EFFICIENCY MANAGEMENT IN POLAND

Abstract

This article includes an overview of methods of energy efficiency improvement in small and medium-sized enterprises (SMEs) applied in Poland. It describes the experience of the implementation of energy efficiency programme in Poland, introduced in 2013 by Polish Agency for Enterprise Development's. Evaluation of the programme shows that energy savings were over 6-times higher than expected by the programme's author before its implementation and amounted to 53 TJ. Financial savings were almost 5-times higher than expected and amounted to PLN 7.3m. Guidelines for decision makers which would be responsible for the development of similar programmes in the future are presented.

Key words:

energy efficiency, energy efficiency measures, energy efficiency programme for SMEs

Introduction

Power engineering is a strategic sector for the European Union [1]. Being the foundation for the functioning of the economy, it enforces the conduct of a responsible and rational policy that can provide energy security. The European Union is the second largest economy in the world and it is responsible for the annual consumption of 1.1 Gtoe of final energy, which constitutes approx. 20% of the global energy generation [1]. Most of this energy comes from import - in 2014 the European Union imported 53.5% of its energy. The dependence is different for each fuel and is the highest for petroleum-derived products – 87.4% of fuels is imported, followed by natural gas (67.4%), whereas the lowest dependence applies for solid fuels, primarily hard coal - dependence on external suppliers is 45.6% [2].

Therefore, due to the high dependence on external suppliers, the issues on efficient use of available resources including energy resource, become extremely important to the EU. Energy efficiency, in addition to reducing the greenhouse gases emission and energy generation from renewable resources, is one of the three pillars of the EU energy policy. "Europe 2020" strategy adopted in 2010 assumes reduction of the final energy consumption by 20% by 2020 [3]. Efforts are made throughout Europe aiming at increasing the energy efficiency, as well as the new responsibilities are adopted, with the perspective of execution by the year of 2030. Due to the specific role of small and medium size enterprises (SMEs) in the construction of economic development in the EU, as well as high energy consumption in this sector, dedicated programs are executed in this group. These actions aim at reducing energy consumption while maintaining at least a constant level of generation.

The issues of energy efficiency are also very important in Poland, and they result from economic and geographic conditions. Annual consumption of the final energy in Poland amounted to 60 Mtoe in 2014, while the annual average increase in demand for energy in the period of 2004-2014 amounted to 0.6% [4]. Along with the increase in demand for energy, the dependence from external supplies of energy resources was growing - while in 2004 Poland imported 14.5% of energy carriers, in the culminating year of 2011 it was already 33.4%. The increase in energy was mainly due to the increasing demand for petroleum, natural gas and their derivatives. In 2014, Poland purchased 72.0% of the annual consumption of natural gas from external partners and 93.1% of petroleum [2]. At the same time, the structure of resources supplies is unfavourable, with the majority of import from one direction - 82% of imported natural gas comes from the East, 13% from the West, and 5% from the South. One of the methods of reducing the demand for energy resources is improving the energy effectiveness. Industry, as a sector that held the third place in energy consumption (24% after housing and transport), is a significant field for taking actions in terms of energy efficiency.

Therefore, the activities of Poland in the field of energy efficiency do not solely stem from acceptance of the EU policy, but, above all, an internal need to build independence in terms of energy resources supplies from foreign partners. The adopted documents specifying the directions of energy policy establish energy efficiency as one of the primary areas of state intervention. The role of industry and entrepreneurs (the SME sector in particular, which dominates in the quantitative structure of enterprises) in the execution of tasks in this area seems to be natural, at the same time, however, the efforts of entities executing the programs for energy efficiency focus on other group of entities. The energy efficiency programs financed by public funds are dedicated to mainly local governments, managers of collective residential buildings and natural persons. Simultaneously, a great potential lies in the modernization of enterprises, which, however is not fully utilized. It is estimated that energy savings potential in European SMEs varies from 10% to 25% in industrial enterprises [5], [6]. At the same time there is an opinion that 40% of this potential might be utilized by implementation of non-investment measures [7]. There are also available other cost-effective energy efficiency measures, but due to several barriers they remain unimplemented. Experts divide these barriers into two types: financial and non-financial ones. Financial barriers include too high investments costs, low capital availability, and low profitability [8]. Non-financial barriers consist of limited in-house skills which would allow to identify and implement energy savings measures, as well as lack of time and difficulties in finding an external professional entity [9], [10], [11]. A well-prepared, SME-dedicated system program could be an impulse for major changes in the field of energy management in enterprises and a significant increase in the improvement of energy efficiency throughout the economy.

The aim of this work is to assess already finished programme, led by the Polish Agency for Enterprise Development (PAED) from 2013 to 2014, and to indicate which aspect of the programme were successful and which were not, so that these result might be used by entities responsible for a development of similar programmes in the future.

Methodology

The analysis was conducted based on two data sources. The first is the Polish Agency for Enterprise Development's (PAED) programme execution report [12], published by PAED. The second source of data are the Author's own analyses, performed based on the data collected during the execution of the program. Specifically, the data from 37 audit reports were included, being in the possession of the Author. 21 out of 37 reports are of Author's authorship. Out of 21 companies that the Author cooperated with, 12 companies decided to implement at least one of the recommendations resulting from audits and the data from these audits served also as the source material.

Energy efficiency improvement in SMEs programme in Poland

Background

The first major energy efficiency programme addressed to Polish enterprises was the project entitled "Testing and Implementing the pilot service in the field of energy efficiency management of enterprises", executed by the Polish Agency for Enterprise Development in the period of September 2013 - October 2014, and then continued until September 2015 by ten accredited entities throughout the country. The project consisted in testing the pilot service, in line with the "Required standard of performance in the field of energy efficiency management of enterprises" (hereinafter referred to as "Standard"). Services were executed in 484 enterprises. The main objective of the project was to verify whether the elaborated standard for the provision of energy audit services for SMEs was correctly identified, and, whether it is possible to achieve the assumed results. The aim of the project, from the point of view of an entrepreneur utilizing the service, was the development of enterprise through the improvement of energy use efficiency - e.g. by optimizing energy consumption, limiting its costs or improving the energy management system in the enterprise. The expected results were also to improve the competitiveness, profitability and potential of the enterprise. The obtained support of the advisory and training character was to help the enterprises in the process of transition from the micro scale to the level of small enterprises and from the level of small enterprises to the medium ones. After completion of the project, the tested service was to be offered by institutions cooperating with PAED on the principles that were to be developed during the project.

Service provision method

All services within the project were executed based on the Standard. The Standard incorporated the definition of energy efficiency, extending the previously used meaning of this term, coming from the Act of April 15, 2011 on Energy Efficiency. This definition added aspects of reducing the energy costs and utilizing the energy from renewable sources, to the technical measures aimed at reducing energy consumption. The measure aimed at improving the energy effectiveness within the meaning of the Standard can be, for example: thermal efficiency improvement of buildings, change of utilized sources and/or energy carriers, elimination of losses in transmission and use of thermal and power energy, the use of waste energy, possibility of selling the surplus of generated energy, monitoring energy consumption, possibility of changing the energy supplier and using special tariffs, reorganization of generation process, optimization of work organization, creation and operation of energy maintenance system, the use of energy from renewable sources and others [13], [14]. The applied approach should be regarded as beneficial from the point of view of the stakeholders of the Programme. It provided a wider range of options for actions for auditors, as it allowed them to include issues on optimization of energy costs (such as changing the energy supplier, changing the ordered capacity, eliminating the costs related to the overrunning of reactive power consumption). Enterprises, on the other hand, received a proposal of actions that are easy to implement, devoid of investment costs and bringing in the short-term cost reduction.

In the Polish legislation, there are no formal requirements specified for the profession of energy auditor. The standard of the service had to determine the requirements for persons who were supposed to conduct the audits. The auditors were presented with the following requirements:

- higher technical or economic education or
- secondary technical or economic education and 3 years of experience in the execution of advisory services regarding energy efficiency of enterprises and
- experience in the execution of at least 5 advisory services regarding energy effectiveness of enterprises gained during 5 years preceding the execution of the service.

Service structure

The service consisted of two stages: the first, compulsory, was an energy audit and usually covered an analysis of the energy management in the enterprise. The second stage, not mandatory, was the implementation of audit's recommendations with the assistance of the auditor. By assumption, the service was to be tailored to the specific nature of the business. The standard of the service assumed that the implementation of measures as part of the first stage was done using methodologies set forth in the relevant laws and regulations regarding energy audits and energy efficiency of enterprises. The audit report had to indicate the measures that would ensure the improvement of energy efficiency of the enterprise by at least 5% or provide the reason for why such savings are not possible to achieve. If the company decided to proceed to the second stage, it would have to perform the measures to ensure the generation of annual savings at the level of 5% minimum. The value of the service performed as part of the first stage amounted to PLN 4,500 (EUR 1,000), while the two stages in total amounted to PLN 10,700 (EUR 2,380). To proceed to the second stage, it was necessary to complete the first stage. Full costs of the service, as part of the programme, were settled as *de minimis* aid, therefore in real terms the enterprise did not incur any costs. Ultimately, the service cost for the entrepreneur was to amount to 30% of the service value, and the remaining 70% was to be covered as *de minimis* aid.

The service was available for micro and small enterprises whose annual energy consumption (including thermal energy, electricity, for transport and others) was no less than 500 GJ (138.9 MWh). In practice, it turned out that not too many micro and small enterprises meet this criterion, therefore the scope of the program was limited to the most energy-consuming industries.

The scope of audit

The energy efficiency audit is performed as part of the first stage of the service, under which the following took place:

- collection of data on energy consumption;
- assessment of the equipment technical condition;
- energy consumption analysis, identification of energy efficiency measures possible to implement and development of simplified economic analysis of these measures;
- indication of the level of energy savings that is possible to achieve;
- analysis of the behaviour of employees and clients;

- formulation of recommendations for introduction of changes in the energy efficiency management in the enterprise.

The audit report contained the characteristics of the enterprise and description of energy efficiency improvement, including, in particular: final and primary energy savings, costs of the measure implementation, financial savings and simply payback time (SPBT), the ecological effect in the form of avoided CO₂ emissions and, in justified cases, life cycle costs (LLC) and life cycle assessment (LCA).

The completion of the audit was to provide the enterprise with the audit report within 21 days of the completion of performance of all measurements and tests. Acceptance of the audit report by the enterprise ended the first stage. The conclusion of co-operation was possible at this stage, or, if the enterprise planned to implement any of the recommended measures, it was possible to proceed to the second stage.

The implementation of one or several recommendations from the previous stage took place as part of the second stage. The implementation could take place in one of the three levels:

- Level 1 - consulting in the implementation of changes in operation of buildings, systems or devices, e.g. by improving the selection of energy tariffs;
- Level 2 - consulting in the proper conduct of maintenance of technical and building infrastructure held in possession;
- Level 3 - consulting in the modernisation process of possessed technical and building infrastructure.

Only the performance of audit and consulting in the implementation of recommendations were financed as part of the programme. Any costs associated with the implementation of undertakings to improve energy efficiency were covered by the enterprise or through the use of external funding sources, but their acquisition was not part of the service.

Programme impact

The size of the programme

The programme was implemented in 484 enterprises throughout Poland. Entrepreneurs operating in the processing industry were the dominant group among the customers of the service (60%). The second largest group, but much less numerous compared to the first one, was comprised of customers conducting business in the retail trade and wholesale sector (10%). The remaining sections of the economy held a share of less than 6% [12].

For most entrepreneurs, the energy efficiency audit service was the first service of this type implemented in their company - 75% of companies never received the offer for a similar service, 55% of enterprises could not find the suitable service on the market, and for 50% of companies this kind of services were too expensive [12].

The results of the audits

Pursuant to the standard of the service, the measures aiming at improving energy efficiency could be, among others:

- thermal efficiency improvement;
- change of utilized sources and/or energy carriers;
- elimination of losses in transmission and in use of thermal energy and electricity;
- the use of waste energy;
- the possibility of selling the surplus of generated energy;
- energy consumption monitoring;
- the possibility of changing the supplier of energy and the use of special tariffs;
- reorganization of the production process;
- optimization of work organization;
- creation and operation of energy management system;
- the use of energy from renewable sources.

In the audits performed by all the entities implementing the project, the most recommended measures covered changes in the operation method of systems and devices and the replacement of devices with new ones, more energy-saving, or modernization and complement of the existing devices and systems. Also, the proposals to implement new procedures and solutions were frequent recommendations, that is - non-investment measures, requiring changes in behaviour and habits of employees. Recommendations on

maintenance, repair of systems, facilities or devices were also popular. All these measures appeared in more than half of the audit reports.

The proposed measures in varying degrees contributed to the physical improvement of energy efficiency in the enterprise. The largest factors were: a change in the operation of systems and devices, training of employees and implementation of procedures and organizational procedures to help reduce energy consumption. Non-investment measures had a large share in the generation of savings, thanks to which it was possible to achieve the assumed increase ceiling of energy efficiency. The structure of the share of individual measures to improve energy efficiency in enterprises are shown in Fig. 1.

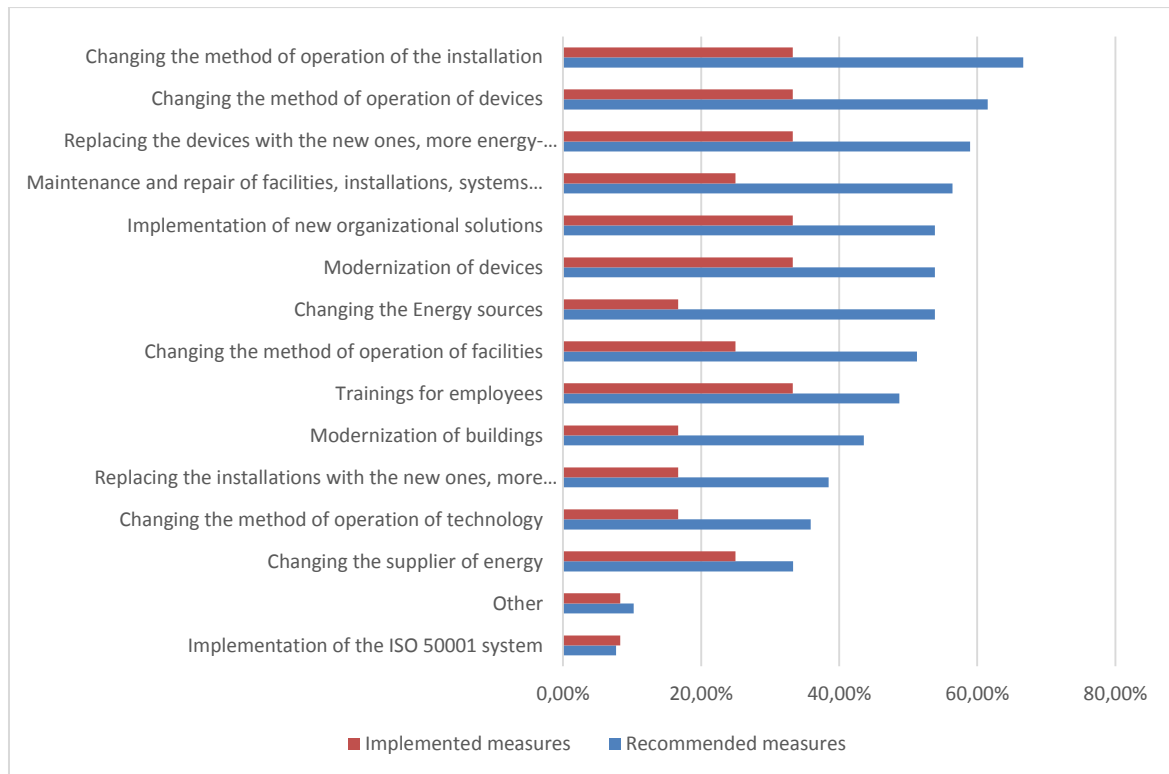


Fig. 1. Recommendations from audits and physical improvement of energy efficiency
Source: own study based on [12]

Implementations of recommendations

The vast majority of solutions proposed in audits were assessed by the enterprise as beneficial, and set for implementation. The most popular were simple non-investment measures, such as a change in the operation of equipment and employees training - 100% of entrepreneurs implemented or planned to implement these recommendations. On the other extreme, there were such measures as an implementation of ISO 50001 standard, a change in the source or supplier of energy - respectively 33.3%, 23.8% and 23.8% of entrepreneurs did not intend to exercise the proposals for implementation of these measures. Given the speed of implementation of recommendations, the measures that were implemented at the fastest rate, right after acquisition of the report, were non-investment measures: trainings for employees, organizational changes, changes in the energy supplier. More complicated measures requiring the investment were deferred, but planned for implementation. These measures comprised modernization of devices and buildings, replacement of equipment, changing energy suppliers, including one's own sources of energy. The structure of implementation in time of recommendations, suggested to enterprises in energy audit reports, is presented in Fig. 2.

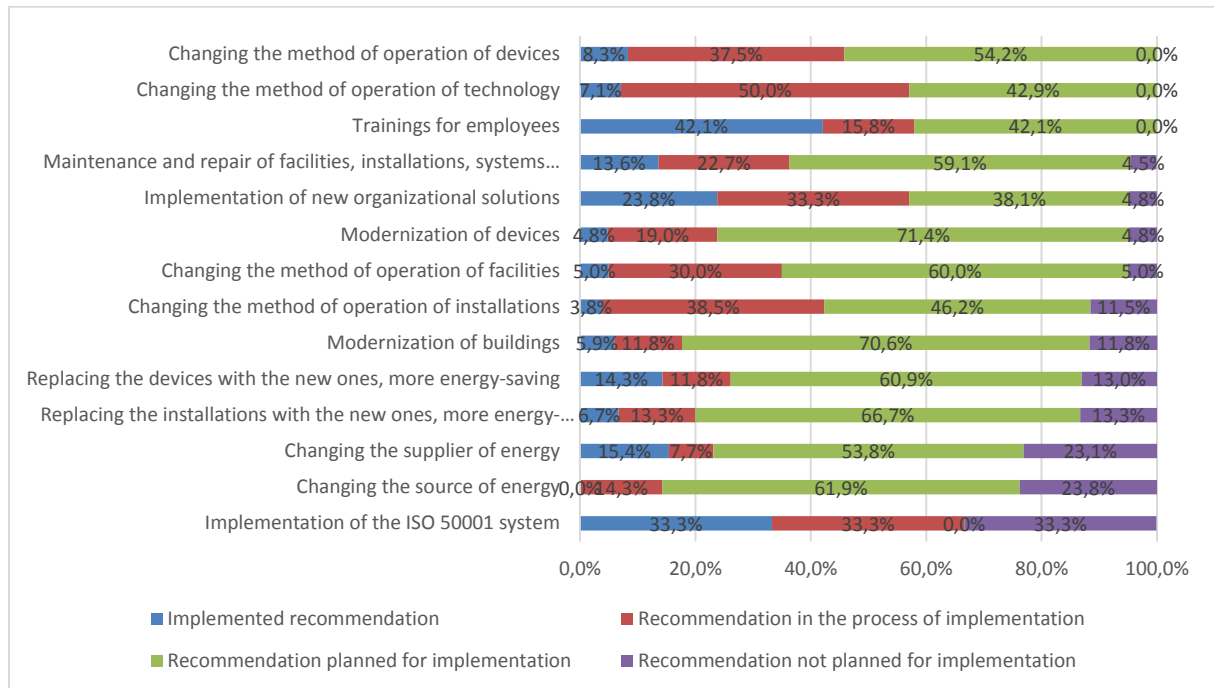


Fig. 2. The progress in implementing the measures recommended in audits

Source: [12]

The main reasons for the lack of implementation of recommendations were financial reasons - more than 40% of enterprises indicated this reason as an obstacle to taking up the measures suggested in the audit. A frequent reason was also the lack of time to implement the recommendations - entrepreneurs tend to focus on developing the core business, whereas the matters related to energy management are ignored and set aside, even if energy costs are a significant part of the budget. The lack of qualifications of employees was a relatively rare issue - it was indicated by only 4.5% of the surveyed companies [12]. The structure of problems in implementation of recommendations is presented in Fig. 3.

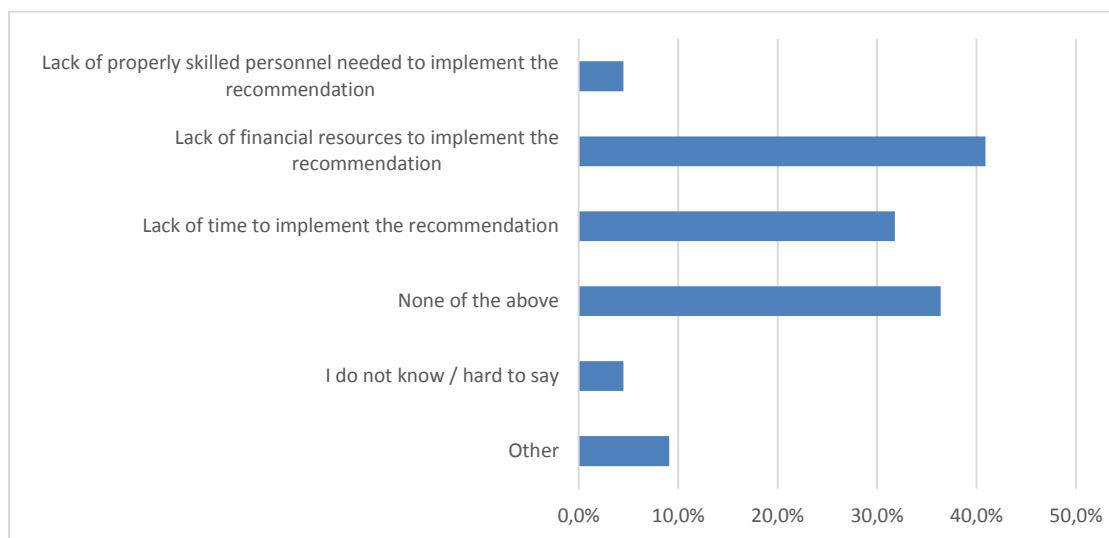


Fig. 3. Problems in the implementation of recommendations

Source: [12]

Program's effects in terms of energy

Pursuant to the provisions of the standard, each of the performed services was implemented in the enterprise consuming no less than 500 GJ of final energy annually. A minimum of 70% of enterprises taking part in the

project were to participate in the second stage of the service, meaning they were to implement recommendations improving the energy efficiency by at least 5%. Against 484 companies that joined the project, the minimum assumed energy savings amounted to 8.475 GJ.

During the implementation of the program it turned out that the assumed minimum is very easy to obtain, which resulted from two factors. The first one was the fact that the implementations executed by enterprises allow the increase of energy efficiency by more than 5% [12]. In 12 companies that cooperated with the author, and which implemented projects indicated in the audit, the average energy savings amounted to 9.25%. The second factor was an annual energy consumption by companies. Despite the fact that the level of 500 GJ was difficult to achieve for most micro and small companies, there are companies, however, which significantly exceed the indicated minimum. Fig. 4 shows the structure of the size of energy consumption by 39 enterprises, the audits of which were available to the author. The dominant group consisted of enterprises with annual energy consumption falling between 500-1,000 GJ. A slightly smaller group, but also numerous, comprised of companies consuming up to 2,000 GJ of energy. There were companies, however, with significantly higher consumption - two companies from the textile industry with consumption of more than 20,000 GJ, but there was also a company manufacturing building materials, with consumption of more than 60,000 GJ. The median of energy consumption among all companies amounted to 1,168 GJ, whereas the average (excluding the three companies with an extremely high energy consumption) – 1,706 GJ.

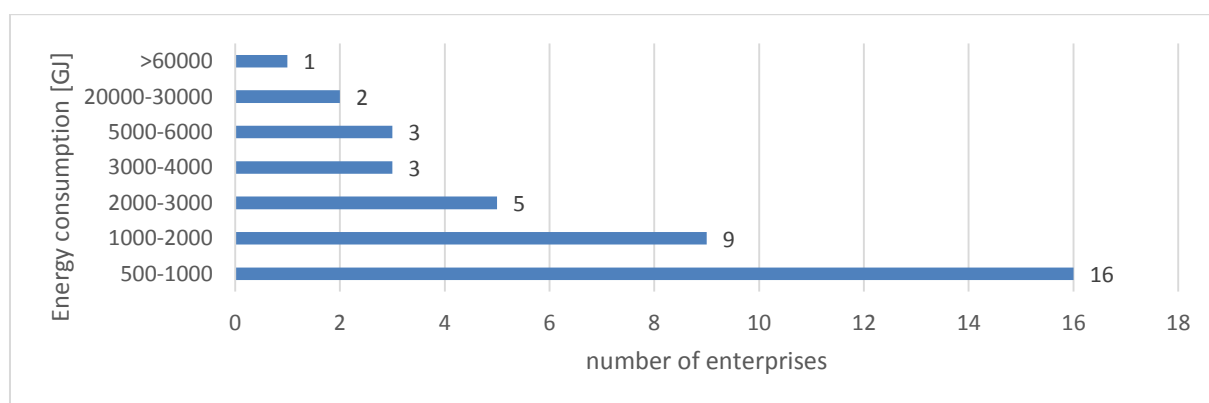


Fig. 4. Size structure of energy consumption by companies.

Source: Author's

Assuming the two means (9,25% - a statistical improvement of energy efficiency and 1,706 GJ - a statistical energy consumption in the company) as global data for the entire project, it can be assumed that the effect of the project implementation is the energy saving amounting to 53,489 GJ. This means that the assumed minimum is exceeded by more than 6 times.

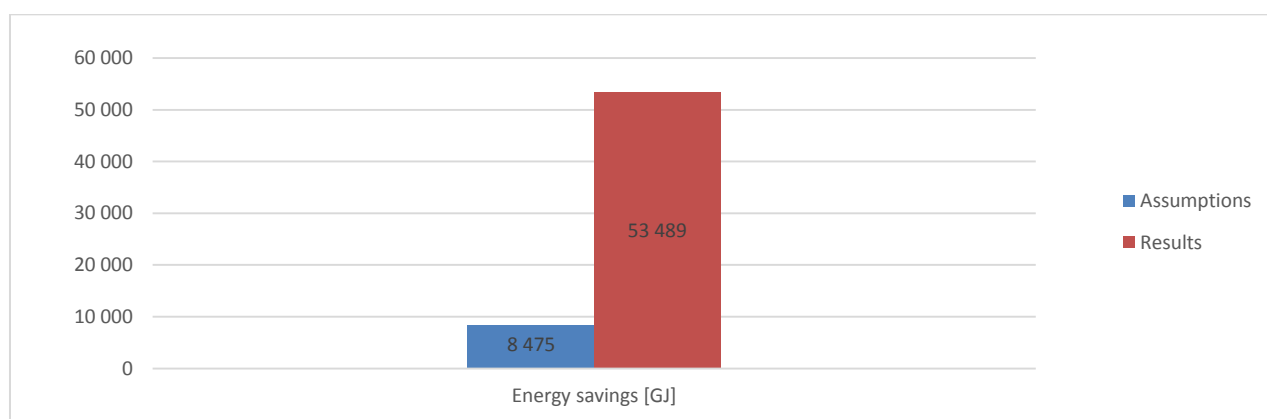


Fig. 5. Comparison of assumed and achieved energy savings

Source: Author's

Exceeding considerably the indicators assumed to achieve the indexes resulted, therefore, from cautious assumptions of the PAED programme. The main factor contributing to the significant increase in energy reduction was the fact of joining the project by a relative large number of enterprises, which were

characterized by higher energy consumption than the threshold ones, representing the eligibility criterion for the project (500 GJ). Moreover, the measures implemented by companies brought energy savings almost twice as great as the required minimum (9,25% against 5%).

Financial effect of the programme

The standard was based on the assumption that the final effect - improvement of energy efficiency of each beneficiary of the service by at least 5% - should cover the costs of energy audit, determined as a standard of PLN 4,500. Therefore, with the assumed structure of services - 70% ended with implementation, the assumed minimum financial effects of the project amounted to PLN 1,525 million in avoided energy costs in enterprises. The evaluation of the project indicated, however, that in 45% of enterprises the improvement of energy efficient amounted to more than 12% [12], in most of the companies, the baseline energy consumption was also higher. In 12 companies that cooperated with the author and which implemented the projects indicated in the audit, the average financial savings in relation to the energy saved amounted to 135.72 PLN/GJ. These profits resulted primarily from the reduced energy consumption, but also from the decrease in unit costs of energy, and the elimination of costs of accompanying measures. As a result, the estimated profits of all the enterprises participating in the second stage, after the implementation of recommendations, amounted to PLN 7.26 million, which is above the assumed minimum effect by 475%. The comparison of assumed and achieved financial savings is presented in Fig. 6.

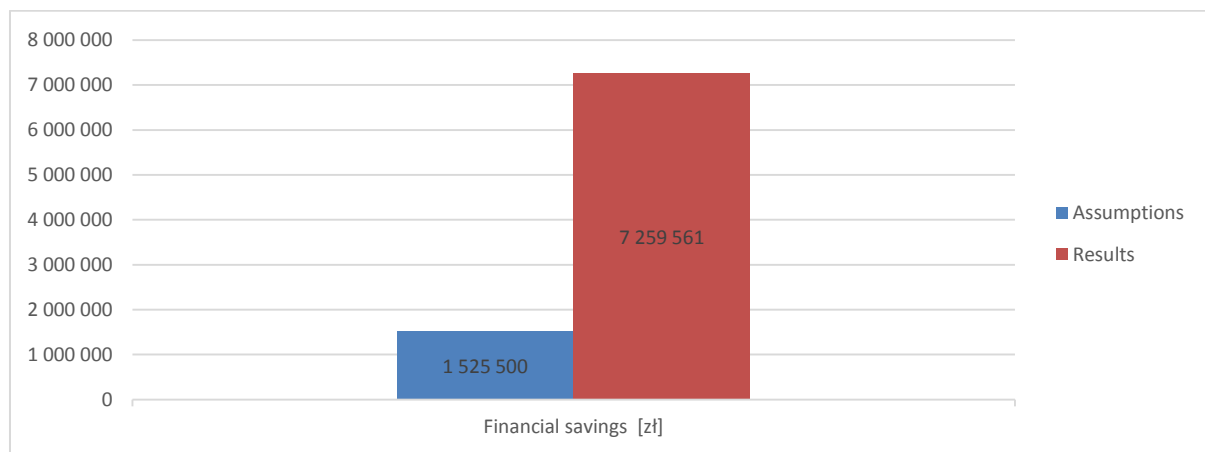


Fig. 6. Comparison of assumed and achieved financial savings

Source: Author's

Ecological effects

Assumptions of the project did not foresee targets for ecological effects. The standard, however, indicated the necessity of calculating the CO₂ for the recommended measures. Referring to the reduction of other pollutants did not fall within the standard. In certain calculations, however, it was justified to calculate ecological effect also in terms of dust emission, SO₂, NO_x and CO. This resulted from the formal requirements of National Fund for Environmental Protection and Water Management in Poland when applying for funding of the measures implementation.

The adoption of a specific methodology of calculating the emission reduction was the author's decision. The author of this work and the three auditors, who shared their audits with the Author, used the following formula:

$$\Delta E_i = \Delta Q_p * e_i$$

Where:

ΔE_i – reduction of emission of compound *i*

ΔQ_p – reduction of consumption of primary energy

e_i – emission indicator of compound *i*

Emission indicators were adopted in line with the current tables published by the National Centre for Emissions Management in Poland.

In 12 companies that cooperated with the author and implemented the undertakings indicated in the audit, the average energy consumption reduction by 1 GJ was associated with the emission reduction of CO₂ by 0.1976 Mg. The estimated effect of the entire project is 10,572 Mg of avoided CO₂ emissions. Given the insufficient amount of data, it is not possible to determine the remaining ecological effects.

Comparison of Polish programme to energy efficiency public programs in selected countries

Energy efficiency improvement programs are implemented in many countries - they were described in, among others: [15], [16], [17], [18], [19], [20], [21]. The authors described the work methodologies utilized in different countries, dependent on local conditions, including the challenges in the field of regional entities' energy management, energy auditors experience, legal requirements or the needs of entrepreneurs. Organizational and financial issues of such programmes were also described. This part of the article presents the comparison of the programmes in Poland, Germany, Italy, Sweden and China.

Measures undertaken in different countries vary in the level of details and target groups. A German project „Sonderfonds Energieeffizienz in KMU” was interesting from the point of view of Polish experiences, in which the performed energy audit authorized to apply for a preferential loan to implement projects aiming at improvement of energy efficiency. The combination of energy efficiency audits with the funding programme resulted in an increased efficiency of the programme in the form of implementations and it was one of the factors, for which the enterprises decided to exercise the audit. Similar experiences were shown by the project executed in Lombardy, Italy. A solution that was also interesting and worthy of adopting was to divide the audits into stages, from which the first one was a description of undertakings, and the second one was a detailed analysis of measures selected by entrepreneurs. Such an approach allows better engagement of entrepreneurs in the process of creation of action plans, which are included in the audit report, and it increases the likelihood of implementation of the recommendations. On the other hand, the Swedish experiences from the execution of the SEAP project - Swedish Energy Audit Programme, show which elements of the energy efficiency audit programmes in the SMEs are not working. The main issue was to ensure a correspondingly high quality level of audits and small possibilities of selecting a company providing audits - both in terms of competence and service costs. Thus, creating a similar programme, it is necessary to create a set of guidelines in line with which the audit should be performed, as well as there should be market conditions created that would make room for the free and natural development of energy services market.

Table 1. Comparison of energy efficiency improvement programmes in selected countries

Country	Poland	Germany	Italy (Lombardy)	Sweden	China
Name	Testing and implementation of a pilot service in the field of energy efficiency management in enterprises	Sonderfonds Energieeffizienz in KMU	n/a (regional project)	SEAP – Swedish energy audit program	Top-1000
Years of implementation	2013-2014	2008-2010	n/a	2010-2014	2006-2010
Target group	micro and small enterprises	SME	SME	SME, large firms in several cases	1,008 largest energy-consuming enterprises (combined accounted for one-third of China's total energy use and almost half of industrial energy use in 2004)
Number of audits	484	4434	71	554 (by 2012)	1008
Audit cost share paid by company	0%	20%	50% (max. 3,000 EUR)	64% (2,700 out of 7,500 EUR in average)	100% After implementation of energy efficiency measure possibility to receive monetary reward of 1.0-1.5 USD for each GJ of saved energy

Source: Author's

Discussion on programme's results

The PAED programme was the first energy efficiency improvement programme in the SME sector in Poland executed on such a large scale. Since it was a pilot programme, it was oriented on testing and verifying the assumed requirements and procedures. The programme's aspects that received a positive verification are:

- the opportunity to include in the audit not only technical improvements, but also financial ones, only lowering the costs of energy, but not its consumption;
- the audit's performance standard referring to the existing standards and legal regulations;
- the report's standard presenting the audit's results in a manner understandable for an entrepreneur, who is not an expert in the field of energy efficiency;
- covering only part of the audit's costs by the enterprise;
- adjusting the scope of the audit to the specifics of a given company - an opportunity to skip these elements of the audit, which hold no significance to the company.

On the other hand, the elements of the programme that require modifications are:

- insufficient level of funding planned for the programme administrative support (30%) - real costs were higher due to increased work input connected with communication with entrepreneurs;
- underrated appraisal of the audit's first stage and overrated appraisal of the other;
- no connection with the programme supporting investments in energy efficiency;
- too high a barrier to entry the programme - the most of micro and small companies in Poland consume significantly less energy than 500 GJ/year.

Next steps

The next steps of the author assume the development of guidelines for entities willing to exercise similar programmes in the future.

Conclusion

Evaluation of the programme "Testing and Implementing the pilot service in the field of energy efficiency management of enterprises", executed by the Polish Agency for Enterprise Development in the period of September 2013 - October 2014 shows that the achieved impact significantly exceeded the initially assumed one, both in terms of energy and financial savings. Nevertheless, since the programme was focused not only on energy savings, but also on verification of the programme assumptions and the methodology, there can be indicated areas which require improvements. The most important ones are the connection between the auditing and the funding programme as well as the decrease of an entry barrier to make the programme more accessible. On the other hand, there are many aspects of the programme that were verified positively and should be replicated in other similar programmes: a wide range of possible improvements which would be proposed to an enterprise (not only technical ones) and a form of the audit report which is written in an easy language which is understandable by no-experts.

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